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Article

Fostering Product Design Innovation: Developing and Implementing an AIGC-Integrated Teaching Model in the "Product Design Process and Methods" Course

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Abstract: This study aims to construct and implement an innovative AIGC-empowered teaching model for the core course "Product Design Process and Methods," with the overarching goal of systematically enhancing students' creative and design capabilities. Guided by the principle of "Cognitive Co-creation," the model establishes a structured and comprehensive teaching framework that spans the entire learning cycle, including pre-class preparation, in-class engagement, and post-class reflection. In the pre-class stage, students engage in targeted research and knowledge acquisition activities, supported by AIGC tools that facilitate information synthesis and ideation. During class, the model emphasizes interactive collaboration and iterative design development, where AIGC-powered platforms assist students in concept divergence, solution generation, and rapid prototyping. In the post-class phase, students refine their designs, produce final presentations, and engage in peer and instructor evaluations, with AIGC providing feedback and analytics to guide improvement. The effectiveness of the model is assessed through practical teaching applications and systematic analysis of student performance, revealing significant enhancements in creativity, problem-solving skills, critical thinking, and collaborative design competencies. The study concludes by exploring future directions, including the integration of 3D generative AI for immersive design experiences, the development of adaptive learning pathways, and the establishment of ethical guidelines to ensure responsible and sustainable application of AI technologies in design education. This research demonstrates that embedding AIGC across the learning process can transform traditional design instruction into a dynamic, student-centered, and innovation-driven educational experience.

Keywords: AIGC; product design education; teaching model; Cognitive Co-creation; Product Design Process and Methods; design innovation

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1. Introduction

Driven by national AI strategies and the global push toward Industry 4.0, the integration of Artificial Intelligence-Generated Content (AIGC) into higher education has emerged as a strategic priority for cultivating future-ready talent capable of addressing complex, technology-driven challenges. Despite its transformative potential, a substantial gap persists between the capabilities of AIGC technologies and their practical application in tertiary design education, where conventional skill-based instruction and manual design processes often predominate. This gap is particularly pronounced in hardware-oriented courses, which demand both conceptual creativity and technical feasibility, yet have historically relied on linear, teacher-centered pedagogy [1].

The core course ″Product Design Process and Methods″ serves as a critical bridge to close this gap, offering a structured platform for embedding AI-assisted innovation directly into the curriculum. Existing literature on AIGC in design education predominantly emphasizes 2D visual creativity, such as graphic design or illustration, while systematic approaches for enhancing 3D hardware product design through AI remain underexplored. Recognizing this deficiency, the present study develops and implements a comprehensive AIGC-empowered teaching model, grounded in the principle of "Cognitive Co-creation", which positions AI as both a collaborative partner and an intellectual catalyst in the design process.

The model strategically integrates AIGC tools across the entire course workflow, encompassing stages such as design research, requirement analysis, conceptual ideation, iterative solution development, rapid prototyping, usability testing, and final presentation. By embedding AI into each phase, students are encouraged to explore unconventional solutions, evaluate multiple design scenarios rapidly, and enhance decision-making efficiency. The effectiveness of this approach is validated through competition-based learning, with award-winning student projects-such as the intelligent *"Smart Pillbox"*-demonstrating significant improvements in creativity, practical problem-solving, interdisciplinary collaboration, and adaptive design thinking [2].

Beyond immediate classroom outcomes, the study provides a replicable framework for integrating AI technologies into higher education design pedagogy, addressing both theoretical and practical imperatives. The approach not only links traditional teaching methodologies with modern technological capabilities but also fosters a holistic educational ecosystem that supports iterative learning, cross-disciplinary knowledge exchange, and reflective practice. Importantly, this framework offers actionable insights into optimizing instructional design, cultivating systems-level thinking, and promoting sustainable, scalable approaches to AI-integrated design education. In doing so, it equips students with the skills, confidence, and cognitive agility required to navigate the increasingly complex, technology-mediated landscape of contemporary product design, preparing them to become innovative, AI-competent designers who can anticipate and address emerging societal and industrial needs [3].

2. Construction of a Teaching Model for AIGC-Empowered Product Design Form Innovation

2.1. From "Tool Assistance" to "Symbiotic Thinking"

The cornerstone of this teaching model lies in a paradigm shift from traditional "tool assistance" toward "symbiotic thinking," in which AIGC functions as an active design collaborator rather than a passive tool. Beyond merely accelerating workflows, AIGC fundamentally reshapes design cognition through its generative and associative capabilities, enabling designers to explore unconventional forms and visual solutions that transcend individual experience. In the context of product form innovation, students begin with vague conceptual keywords or abstract ideas, which are then processed by AIGC to generate multiple visual interpretations [4]. This approach breaks cognitive fixedness, inspires non-linear thinking, and initiates a dynamic creative cycle described as "human proposes, AI generates and expands, human evaluates and optimizes." Over time, this iterative collaboration nurtures students' ability to integrate human intuition with AI-driven exploration, promoting a higher level of creative confidence and ideation depth.

2.2. Teaching Model Framework Design

Building upon the principle of "symbiotic thinking," this study constructs a comprehensive AIGC-empowered teaching model that spans the full learning process: pre-class preparation, in-class engagement, and post-class reflection. The objective is to seamlessly integrate AIGC tools into the existing framework of the "Product Design Process and Methods" course, establishing a standardized, reusable, and scalable pedagogical structure that can guide both instructors and students through AI-assisted design workflows.

2.2.1. Technical Foundation and Ethical Priming

The technical foundation and ethical priming stage constitutes a critical prerequisite for successful implementation. Instructors are responsible for two core tasks: selecting appropriate AIGC tools and developing tailored instructional content. Tool selection involves evaluating AIGC platforms for compatibility with course objectives-for instance, Midjourney can serve as the primary tool for creative concept divergence, while modeling software integrated with AI functions enables precise control of form, perspective, and 3D visualization. Content development emphasizes the translation of design objectives into AI-compatible input prompts, teaching students to articulate materials, styles, forms, and human-computer interaction relationships effectively. Students, in turn, are trained to achieve technical literacy and to internalize principles of responsible AI use, understanding the boundary between original and AI-generated content. This ethical priming ensures that students leverage AI to enhance creativity without over-relying on it to complete their design projects, fostering a balance between technological assistance and human ingenuity.

2.2.2. Deep Coupling of AIGC and the Design Process

This stage represents the core of the teaching model, embedding AIGC deeply into four key phases of the design process:

Stage 1: Design Research & Mood Board Generation. Students employ AIGC to synthesize preliminary findings from user and market analysis into visually rich lifestyle images, emotional boards, and diverse aesthetic representations of potential products. This rapid visualization process helps teams define the design direction, identify target user needs, and establish a coherent aesthetic tone, thereby accelerating decision-making and fostering a shared design language.

Stage 2: Concept Divergence & Form Explosion. At this stage, AIGC operates as a true "collaborator." Students begin with free-form text prompts to explore creative possibilities, followed by hand-drawn sketches augmented by "image-to-image" AI functions for rapid iteration. This methodology generates a large repository of form alternatives, effectively overcoming personal cognitive limitations and producing a "form library" that significantly expands the design solution space, enhancing originality and diversity.

Stage 3: Scheme Development & Multi-dimensional Evaluation. For selected concepts, AIGC is utilized to produce multi-angle views, detailed close-ups, and contextually realistic application scenarios. Students can evaluate volume, proportion, and CMF (Color, Material, and Finishing) aspects more scientifically and efficiently, enabling data-informed design decisions that integrate aesthetic judgment with technical accuracy.

Stage 4: Final Presentation & Storytelling. In the final stage, AIGC transforms into a high-fidelity "visual translator," generating photorealistic renderings and narrative-driven usage scenarios. This enhances the clarity, persuasiveness, and visual impact of students' final presentations, effectively conveying design intent to instructors, peers, and external audiences.

2.2.3. Extension and Application - Closing the Loop with Competitions

The model extends beyond standard course assignments, actively connecting student outputs to high-level competitions such as the "UXDA International User Experience Innovation Competition." By guiding students to refine their AIGC-assisted projects for competitive contexts, the model creates a closed loop of "Learning → Competition → Research." Competition outcomes serve as robust validation of the teaching model's effectiveness, while feedback from these events informs continuous improvement of instructional strategies. Concurrently, this process cultivates comprehensive practical skills, strengthens students' confidence in innovation, and provides real-world exposure to the integration of AI technologies in professional design practice. By embedding these mechanisms, the teaching model not only enhances individual creativity but also prepares students to navigate the evolving landscape of AI-assisted product design.

3. Teaching Practice and Outcome Verification through "Competition-Driven Learning"

3.1. Overview of the Practical Course

This teaching reform initiative was implemented within the core course "Product Design Process and Methods" for undergraduate product design majors. The student cohort consisted of second-year undergraduates who had already acquired foundational design thinking and modeling skills, placing them at a pivotal stage for cultivating innovative capabilities. The course spanned 16 weeks, encompassing a total of 64 class hours, and adopted a blended teaching approach that integrated theoretical lectures, hands-on workshop training, and competition-based practice.

In practical implementation, an AIGC toolchain was established, utilizing platforms such as Midjourney, Deepseek, and Doubao to facilitate rapid conceptual divergence. This toolchain enabled students to expand research ideas broadly, exercise precise control over stylistic features, and generate multi-view representations of design concepts efficiently. Pedagogically, AIGC tools were embedded as a central thread throughout the entire design process, from initial research to final expression, ensuring that AI integration was consistent, meaningful, and seamlessly connected to learning outcomes. The project framework was anchored in the design brief from the UXDA International User Experience Innovation Competition, providing students with authentic challenges that required mastery of human-AI collaborative processes. This approach achieved the dual objective of promoting learning through competition while simultaneously advancing research-informed design practices.

3.2. AI-Powered Smart Pillbox for the Elderly (National 2nd Prize, South China Regional Silver Award)

Centered on the 2025 UXDA theme, this project applied human-centered design principles to develop AI-assisted products for elderly users. Initial concepts, focused on creating an "approachable" and "reliable" medication management system, were generated using AI prompt engineering, enabling students to rapidly explore diverse design possibilities.

Iterative refinement of the medicine box's compartment structure and reminder system was accomplished by combining traditional sketches with image-to-image generation, integrating Near Field Communication (NFC) pop-up design to reduce software usage barriers for elderly users and improve overall convenience. As shown in Figure 1, AI facilitated the scanning of drug information, hardware components, and NFC patches, providing a seamless interface between physical and digital interaction.

Figure 1. AI scans drug information, hardware products, and NFC patches.

To validate design rationality, usage scenarios reflecting typical home environments of elderly users were created by combining animations generated with software such as

Sora and live-action footage. Physical prototypes were produced and subjected to user testing, confirming usability and ergonomics. AIGC contributed to enhancing the product's affinity through form semantics, while visualized light and sound alerts further improved the age-friendly nature of the hardware interaction, ensuring the product was intuitive, accessible, and emotionally engaging.

3.3. Typical Case Study II: AI-Guided Antu Device (National Third Prize Winner)

Also aligned with the UXDA 2025 theme, this project explored age-inclusive AI product design in the context of smart elderly care. By analyzing user pain points and social needs, the design addressed the requirements of both elderly users and their adult children, resulting in two distinct sets of UI interfaces and UX operation flows tailored for different user groups.

In response to safety concerns such as elderly disorientation and mobility limitations, the project envisioned the future of smart mobility in elderly care, emphasizing navigation devices and user experiences within a 1-kilometer radius of home. AIGC was leveraged to generate modeling concepts for an elderly-friendly drone, combining a technological and guidance-oriented aesthetic with dynamic video scenarios illustrating practical usage. As shown in Figure 2, AI-generated images were incorporated into project presentations to demonstrate device functionality, interactive logic, and scenario-adaptive operation.

Figure 2. Dynamic images generated by AI in project presentations.

The integration of projection and touch-based control allowed for rapid visualization of the device's multi-dimensional interactions, encompassing hardware, software, and user considerations in age-adapted scenarios. Through this competition-integrated AIGC practice, students not only explored innovative interaction paradigms but also developed a deeper understanding of scenario-adaptive design, human-AI collaboration, and the translation of conceptual design into functional, user-centered products. This process validated the practical effectiveness of the teaching model while simultaneously cultivating students' creativity, technical proficiency, and problem-solving capabilities within authentic, real-world contexts.

4. The Core Value of AIGC in Empowering Teaching

This teaching reform practice demonstrates that the deep integration of AIGC has introduced multi-dimensional core value innovations to product design education, fundamentally reshaping both the pedagogical process and students' creative capabilities.

First, in expanding the boundaries of innovation, AIGC enables exploration of previously "impossible" design possibilities in form generation. Functioning as a "super external brain" with access to vast databases and cross-disciplinary associative capabilities, AIGC can generate novel forms, structures, and CMF (Color, Material, and Finish) combinations from vague or abstract prompts, far surpassing the scope of students' individual experience and imagination. This capability allows students to conceive forward-looking, highly original design schemes at the conceptual stage, breaking through early cognitive constraints that traditional sketching or modeling often imposes. By providing immediate exposure to unconventional alternatives, AIGC effectively elevates the ceiling of formal innovation, encouraging experimentation with ideas that might otherwise be dismissed due to perceived technical or aesthetic limitations.

Second, in accelerating iterative cycles, AIGC drastically reduces the time required to transform ideas into visual representations. In conventional design practice, refining a complex form often demands substantial time for manual drawing, digital modeling, or physical prototyping. In contrast, AIGC's text-to-image and image-to-image capabilities can generate dozens, if not hundreds, of visual variants within minutes. This rapid prototyping allows students to simultaneously compare, optimize, and iterate on multiple design solutions, shifting the design process from a linear, sequential workflow to a parallel, explosive mode of exploration. The near real-time feedback loop not only enhances efficiency but also fosters adaptive thinking, enabling students to make informed design decisions more quickly and confidently.

Finally, in strengthening narrative and communication capability, AIGC significantly enhances the expressiveness, clarity, and persuasiveness of design outcomes. By producing high-fidelity product renderings and realistic application scenarios, AIGC allows students to construct comprehensive, visually compelling design narratives that communicate both functional intent and emotional resonance. This capacity trains students to integrate technology, aesthetics, and user experience into cohesive storytelling, an essential skill for professional practice. The ability to craft vivid, contextually grounded design stories not only improves the professional quality of student presentations but also cultivates the capacity to justify design decisions, articulate design rationale, and engage stakeholders effectively.

Overall, the integration of AIGC in teaching transcends traditional tool-based assistance, offering students an enriched environment where creativity, efficiency, and narrative expression are simultaneously amplified. By leveraging AI as an active collaborator, students are equipped to explore innovative concepts with unprecedented freedom, iterate rapidly on complex ideas, and communicate their design intentions with heightened clarity and impact, thereby establishing a new paradigm for AI-augmented product design education.

5. Conclusion and Outlook

This study successfully developed and implemented an AIGC-empowered teaching model for the core course "Product Design Process and Methods," effectively addressing the gap between national AI education strategies and classroom practices in design education. Centered on the concept of "Cognitive Co-creation," the model integrates a carefully designed AIGC toolchain throughout the entire learning process, encompassing pre-class research, in-class iterative development, and post-class reflection and presentation. By embedding AI tools at each stage, the model significantly enhances students' innovation efficiency, broadens the scope of exploratory design possibilities, and encourages the generation of original, forward-looking solutions in hardware product form and styling.

The practical application of this model has been validated through competition-driven learning and the production of award-winning student projects, demonstrating improvements not only in technical proficiency and design quality but also in students' confidence in innovation, problem-solving capabilities, and ability to navigate complex design challenges collaboratively. Additionally, the integration of AIGC has fostered faculty development, enabling instructors to explore new pedagogical strategies, facilitate AI-human collaborative learning, and adapt traditional curricula to the demands of a technology-driven educational landscape.

Looking ahead, future research and practice will focus on several key directions. First, the integration of 3D generative AI is expected to provide immersive design experiences, allowing students to engage with volumetric and spatial exploration in ways that surpass current 2D and static modeling methods. Second, the scope of AIGC application will be expanded across the entire product design chain, including ideation, prototyping, user interaction simulation, and lifecycle evaluation, creating a more holistic AI-augmented learning environment. Third, establishing robust evaluation criteria and ethical guidelines will ensure responsible and sustainable use of AI in education, protecting intellectual property, promoting originality, and balancing human creativity with algorithmic assistance.

Overall, this study demonstrates that deep integration of AIGC in design education is not merely a technological enhancement but a transformative pedagogical approach that cultivates future-ready designers, bridges the gap between traditional teaching and emerging AI capabilities, and contributes to the high-quality development of the design and manufacturing sector. By continuously refining this model, educators can create an adaptive, scalable, and ethically responsible framework that equips students to thrive in increasingly AI-driven design industries, fostering innovation, interdisciplinary thinking, and professional excellence.

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